JPRS 77757

6 April 1981

China Report

SCIENCE AND TECHNOLOGY

No. 92

FBIS FOREIGN BROADCAST INFORMATION SERVICE

NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service, Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semi-monthly by the National Technical Information Service, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Indexes to this report (by keyword, author, personal names, title and series) are available from Bell & Howell, Old Mansfield Road, Wooster, Ohio 44691.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

NOTICE

Beginning with this issue, Hong Kong media reportage on the People's Republic of China and all material on Taiwan dealing with science and technology will be published in this report rather than in the JPRS SOUTH AND EAST ASIA REPORT, where it appeared heretofore.

JPRS 77757

6 April 1981

CHINA REPORT

SCIENCE AND TECHNOLOGY

No. 92

CONTENTS

PEOPLE'S REPUBLIC OF CHINA

NATIONAL DEVELOPMENTS

Present, Future Application of Scientific Decisionmaking
(Wang Shouyun; GUANGMING RIBAO, 16 Dec 80) 1

APPLIED SCIENCES

Multimode Automatic Tracking System Use in Satellite Communications Described
(Cao Juliang, Wu Deyan; DIANZI JISHU, No 8, 1980) 5

Shipboard Data Multiplex System Described
(Zhu Wuhua, Wang Hongzhen; DIANZI JISHU, No 8, 1980) 26

Briefs

Chinese Language Letterpress 33

ABSTRACTS

PETROLEUM

SHIYOU XUEBAO [ACTA PETROLEI SINICA], No 4, 1980 34

NATIONAL DEVELOPMENTS

PRESENT, FUTURE APPLICATION OF SCIENTIFIC DECISIONMAKING

Beijing GUANGMING RIBAO in Chinese 16 Dec 80 p 3

[Article by Wang Shouyun [3769 1108 0061]: "Using Science and Technology To Realize the 'Scientification' of Policymaking"]

[Text] "Scientification of decisionmaking" is a phrase devised to explain the argument of the "artistic" method versus the experience method of decisionmaking. Of course, condemnation for issuing willful and confused orders is also implied.

In 1806, the Prussian military reformist Gerhard Johann David von Scharnhorst created the general staff system, with which he expected to raise military decisionmaking from a kind of "art" to a field of science. The French scientist André Marie Ampère proposed the need of a science to study the state management in a book he published in 1845. In the past two centuries, many have tried to improve the method of making decisions, in an attempt to cause decisionmaking to be less and less a matter of "art" and more and more a matter of science.

Scientific decisionmaking was adopted the earliest in the realm of military command. Scientification of military command decisions means a scientific system of information decisionmaking and a system of advisory staff policy determination, as well as the quantification of the method of decisionmaking itself. The process of scientification of military command decisionmaking has had a profound effect on the process of scientification of decisionmaking in the realms of society, economy, and political affairs.

Shortcomings exist in China's current system of making political and economic decisions, but if the knowledge means, and organizational methods of national defense science and technology, which China has developed and mastered, are fully utilized, it will be possible to overcome these shortcomings and an important step toward scientification of decisionmaking will have been realized.

Military information technology should be adopted to serve the scientification of civilian decisionmaking as quickly as possible.

For the purpose of making decisions, it is necessary to use a certain method to gather, process, transmit, and utilize information--i.e., to establish a certain information system. The military information system is the earliest to be established and the most efficient. The oldest system of transmitting intelligence data and orders is the fenghuotai [beacon fire] and the message dispatcher. The command headquarters, using telegraph lines, is a system established in the middle of the 19th century. Early in the 20th century, the general headquarters system using radio telecommunications technology was established. Toward the end of the 1950's, the modern command control system using electronic computers and a data transmission network was developed. The above is a simple picture of the development of the military information system.

In May 1980, China organized the information system of commanding the launching of a carrier rocket in the Pacific Ocean. This is a type of nationwide information system managed through the use of electronic computers. It uses electronic computers and multiple data transmission channels, and it proceeds in a timely manner with the gathering, coding, transmission, editing, storage, searching, dispatch, and display of related information distributed in information sources all over the country to supply the needs of decisionmaking or to store in a central data bank to be randomly accessible to the decisionmaking organization. The efficiency of the process between information and decisionmaking is thus greatly improved.

In developed capitalist countries, this type of information system, managed by computers, was first developed by the military command department and extended to the departments of industry, finance, commerce, trade, and administration at the beginning of the 1960's. Similar "command control centers" were established to form the information management system for the purpose of supplying information to management. At present, China remains backward with respect to gathering, transmitting, processing, and utilizing management information. Statistical data are incomplete, inaccurate, not very reliable, and slow in transmission and feedback; these shortcomings often cause errors in management decisionmaking. The technology of the command information system of defense technology experiments which has been mastered in China can be extended for civilian use to help establish an information management system for large enterprises, or even an information system of the entire national economic construction, so that a firm material foundation may be laid for scientification of decisionmaking.

Organize and establish a general staff decisionmaking mechanism with the participation of scientists and engineers.

At the beginning of the 19th century, a relatively perfect general staff system was created for Prussian troops, indicating that there was a need at that time for the military commanders' decisionmaking process to be supported by the collective wisdom of the staff. This is the first important development of the staff decisionmaking mechanism. During World War II, there was a massive struggle on both sides to develop, deploy, and apply advanced military technology. Scientists and engineers were in urgent demand to participate in the decisionmaking process. At that time, there were no fewer than 700 scientists and engineers engaged in the work of strategy and policy research in the United States, England, and Canada. Their work had a profound effect on the participation of scientists and engineer in the decisionmaking service after the war in every country. Scientists and engineers as a body became part of the decisionmaking process. This was the second important development in the staff decisionmaking mechanism. In 1948, the U.S. Air Force created the Rand Corporation. In the 1950's, China's department of defense technology established a system engineering general design organization. These represent two types of effective forms of development. These two forms, as well as the ordinary form of general staff, are indispensable for a complete staff decisionmaking mechanism.

The Rand Corporation is a research organization set up to provide technical service for strategic decisionmaking. It studies new concepts, new ideas, new theories, and new methods for the realization of optimal decisionmaking. It uses the results of its own research to enrich the wisdom of decisionmaking agencies. The results of its research have had profound effects on the formation and development of U.S. strategic theories and national defense policies. The Rand Corporation has become an indispensable "think tank" in the decisionmaking chain of U.S. military, political, foreign, and social affairs.

In the 1950's, when China moved forward her plan of developing sophisticated defense technology, a new type of staff mechanism--a general design organization of system engineering--was established. It has made important contribution to China's success in artificial satellite and guidance missile plans. This general design organization is to provide technical service for strategic decisionmaking. It takes a series of moves required for the realization of a specific planned goal, considers them to be systems with strict organizational structures, and proceeds with the programming, design, execution, and coordination so as to guarantee that in the decisionmaking system, every tactic is technically and economically feasible and all tactics are mutually coordinated to the extent that certain standards may be used to determine the optimal form to realize the goal being planned. It designs the technical route to realize the specific plan, the technical program, and the structure of the target system. Based upon this type of movement strategy, the decisionmaking agency makes choices and implements the final decision. When Zhou Enlai was alive, he had hopes of applying the experience of the general design organization to important engineering constructions of the national economy. Most recently, Chinese scientists and technicians proposed the establishment of a general design organization for the national economy, so as to extend the object of application of the general design organization from individual military engineering projects or economic construction engineering planning to the overall planning of the national economy. Natural scientists, social scientists, specialists of engineering technologies, and management specialists are to be organically organized into this national economy general design organization to jointly design national economic construction programs, which are to include industries, agriculture, transportation, communication, energy sources, education, science and technology, population, national defense, and people's livelihood, for the reference of the leadership agencies of the state in their policy decisionmaking process. This type of program has been tested as to feasibility and has been measured and compared. It is quantitative. The experience of China's general design organization for the development of its defense science and technology can be applied to establish a general design organization for large-scale economic construction engineering and the national economy.

Application of modern science and technology to the quantification of decisionmaking.

Historically, many scientists, such as Archimedes, Da Vinci, Galileo, [Tadeusz] Reichstein, Edison, etc., all attempted to use the method of natural sciences to analyze war operations. The early stage work of war analysis begot the seeds of new ideas. Model methods and simulation experiment methods of natural science and engineering technologies are applied for the quantification of decisionmaking. During World War II, large groups of scientists and engineers worked conscientiously and in an organized manner to cause these seeds to bloom and bear fruits. Decisionmaking, a field traditionally dependent upon artistic skill to handle problems, has given birth to a science--operational research--to supply quantitative data to be used as bases to adopt strategies by leadership agencies regarding affairs and activities under their control. As early as 1956, a group of far-sighted Chinese scientists established an operational research organization. Today, it is being used for quantification of decisionmaking in operational research, topology, decisionmaking theory, mathematical programming, network analysis, optimal control theory, graphic analysis, production analysis, and forecast theory. All of these have had considerable development. In 1979, Qian Xuesen [6929 1331 2773] and Wu Jiapei [3527 1367 1014] proposed to apply systems engineering, which has operational research as its foundation, to the macroeconomic movement of the entire country, to establish social engineering in order to realize quantification of decisionmaking in national economic construction. Concretely speaking, statistical data are timely supplied to the national economy information system, mathematical models of macroeconomy are correctly built, simulation experiments of economic construction programs are carried out on electronic computers, choices among plans and programs are made on the basis of the result of quantified experiments, and plans and programs are adjusted in a timely way according to the changing condition of execution of the national economic plan and new developments in politics, economics, and science and technology. This is the general process of realization of the quantification of decisions regarding the national economy.

6248
CSO: 4008

MULTIMODE AUTOMATIC TRACKING SYSTEM USE IN SATELLITE COMMUNICATIONS DESCRIBED

Shanghai DIANZI JISHU [ELECTRONICS TECHNOLOGY] in Chinese No 8, 1980 pp 4-11

[Article by Cao Juliang [2580 5418 5328] and Wu Deyan [0702 1795 3508]: "Multimode Automatic Tracking Systems in Satellite Communications"]

[Text] 1. Introduction

In satellite communications, in order to enable a ground station antenna to track a satellite, automatically, either automatic tracking or program control is generally used. In implementing the automatic tracking method, beam control, multihorn tracking, step tracking, multimode tracking and the like can be used.

In the beam control method, the rotation of the antenna beam induces communications signal amplitude modulation, and when more than two ground stations use this method there may be a rather large tracking error, so that currently the method is little used.

The multihorn method was used in the Fuqinuo [phonetic] and Zhanmusibao [phonetic] stations. But because it is very complex and makes increasing the antenna gain difficult, it too is little used.

The step tracking method increases or decreases the antenna direction angle by fixed steps of about 0.01°; if after a step the signal received is greater than before the antenna continues stepping in this direction; but if after a step the signal is weaker, it changes its step direction (reverses). It is one of the maximum-value tracking systems, and its tracking precision and acquisition speed are not as good as zero-value tracking systems.

The basic principle of the multimode tracking system is that when the antenna is completely aligned on the satellite, the electromagnetic field excited in the feeder horn of the ground station by the electromagnetic wave emitted from the satellite consists only of the fundamental mode, but when the antenna deviates from the satellite direction the electromagnetic field excited in the horn includes not only the fundamental mode but higher modes. The characteristics of these modes within the waveguide can be used to obtain the fundamental mode as a sum signal and the high harmonics as a difference signal, and after synchronous detection by the tracking receiver a voltage representing the angular deviation of the antenna beam from the direction to the satellite is obtained, which can be fed to the servosystem that drives the antenna, achieving the goal of automatic satellite tracking. Multimode tracking is a zero-value method, with superior tracking capabilities, and in the last decade it has come into extensive use in satellite ground stations and tracking and control stations.

In the program control tracking method, the difference between the angular values of the direction in which the antenna should be pointing and the digital angular value of the actual antenna direction is calculated, and a stored program computer is used to control the antenna and reduce the deviation to zero. The program control method is essential for moving satellite systems. But for stationary satellite systems, it is used only as an auxiliary method of tracking. The Ibaraki and Yamamoto stations in Japan use this method, but for economic reasons most ground stations do not use it.

This article introduces the multimode automatic tracking method, which is currently in extensive use in satellite communications.

2. The Operating Principles of Multimode Tracking

When multimode tracking is used, the ground station's antenna feeder horn must be a multimode horn. If a conical horn and a round waveguide are used as a feeder system, the fields induced in the round waveguide may include the TE_{11}, TM_{01}, TE_{21} and TE_{01} modes (see Figure 1), of which the TE_{11} is the fundamental satellite communication mode. For large-aperture open round waveguides ($D/\lambda << 1$, where D is the diameter of the opening of the round waveguide and λ is the working wavelength), the fundamental mode radiation pattern has a single peak, while the higher mode radiation pattern has a double peak as shown in Figure 2. We may consider that the antenna's radiation characteristic applies to both radiation and reception, and accordingly when the antenna receives a signal from the satellite it also has the characteristics shown in Figure 2, so that when the satellite is located on the antenna axis (the direction of maximum radiation of the basic mode), only the TE_{11} mode will be excited in the waveguide: if the satellite is off the antenna axis, not only the basic mode but also the harmonics such as TM_{01}, TE_{21} and TE_{01} will be excited in the waveguide. A mode coupler can be used to obtain the fundamental model component (generally called the "sum signal") and the higher mode component (the "difference signal"), as shown in Figure 3. It can be seen from Figure 2 that when the angle θ by which the satellite is off the antenna axis is small, the sum signal amplitude is unchanged, but the difference signal amplitude varies in proportion to θ. If the beacon signal emitted by the satellite has an angular frequency of ω, then by passing the sum and difference signals through a multiplier (phase detector) an output which is proportional to these signals can be obtained, with a direct-current component proportional to θ and a higher harmonic component proportional to the angular velocity 2ω: if the high harmonic component is filtered out and the direct-current component is fed to the antenna servo drive system, the antenna beam can be directed toward the satellite, causing θ to decrease toward zero. The angle θ as shown in Figure 2 is generally called the tracking error, and the output after phase detection as shown in Figure 3 is generally called the angular error voltage.

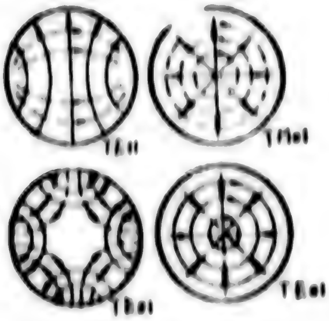


Figure 1. Electric Field Distributions of Various Modes in Round Waveguide
(——— electric fields; - - - - - - - magnetic field)

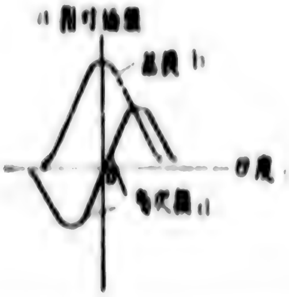


Figure 2. Radiation Characteristics of Fundamental Mode and Higher Modes at Round Aperture Plane

Key: a. Relative field strength
b. Fundamental mode
c. Degrees
d. Higher modes

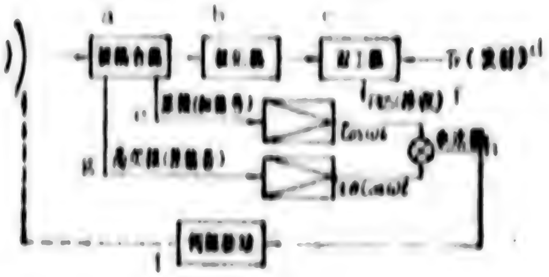


Figure 3. Principle of Multimode Automatic Tracking

Key: a. Mode coupler
b. Polarizer
c. Diplexer
d. Transmitter
e. Fundamental mode (sum signal)
f. Receiver
g. Higher modes (difference signal)
h. Multiplier
i. Servo drive

The type of automatic tracking described above is one dimensional, but in satellite ground station antennas, in order to align the beam from the antenna on the satellite and assure peak antenna gain and thus optimum system efficiency, a two-dimensional tracking method which simultaneously controls elevation and azimuth must be used. In view of amplitude error alone, for two dimensional tracking two higher modes are needed in addition to the fundamental mode, i.e., a higher mode excited only by the horizontal component of the tracking error and another higher mode excited only by its vertical component; thus a three-mode signal is needed. However, in practice, in addition to the fundamental mode, not only the amplitude characteristic of the difference signal but also the phase difference between the sum signal and the difference signal is used, so that although only two modes are used (for example TE_{11} and TM_{01}), two dimensional tracking is still possible; or if in addition to the main basic mode two orthogonal components of the higher modes are used, it is also possible to use only two modes (for example TE_{11} and TE_{21}) for two dimensional automatic tracking.

A. Radiation Characteristics

For a large aperture open circular waveguide ($D/\lambda \gg 1$), if the electromagnetic field distribution over the plane of the opening is the same as that within the waveguide, neglecting the noncontinuous nature of the waveguide opening, the electromagnetic intensity at a point P in the distant radiation field of modes TE_{nm} and TM_{nm} can be expressed as:

for the TE_{nm} wave,

$$\left.\begin{aligned} E_\theta &= E_0 \frac{J_n(u)}{u} n \sin n\phi \\ E_\phi &= E_0 \frac{J_n'(u)}{1-\left(\frac{u}{k_m' a}\right)^2} \cos n\phi \\ E_R &= 0 \end{aligned}\right\} \quad (1)$$

for the TM_{nm} wave,

$$\left.\begin{aligned} E_\theta &= E_0' \frac{u J_n(u)}{1-\left(\frac{u}{k_m a}\right)^2} \cos n\phi \\ E_\phi &= 0 \\ E_R &= 0 \end{aligned}\right\} \quad (2)$$

where

$$u = \frac{2\pi a \sin\theta}{\lambda} = ka\sin\theta; \quad (3)$$

The coordinates of point P (R, θ, ϕ) are shown in Figure 4; in the formula above a is the radius of the open end of the circular waveguide, λ is the wavelength in free space, and k is the corresponding wave number. J_n is the class 1 Bessel coefficient of order n, $k_m a$ is the m-th root of $J_n(x) = 0$, and $k_m' a$ is the m-th root of $J_n'(x) = 0$. E_0 and E_0' are arbitrary constants used to normalize the voltage gain of the TE_{11} mode axial radiation. Figure 5 shows the radiation direction patterns for the commonly used TE_{11}, TM_{01}, TE_{21} and TE_{01} waves. Half of the radiation pattern is given, and the other half is symmetric with respect to the axis. It can be seen from the a patterns that TE_{11} has a single peak whereas TM_{01}, TE_{21} and TE_{01} have double peaks.

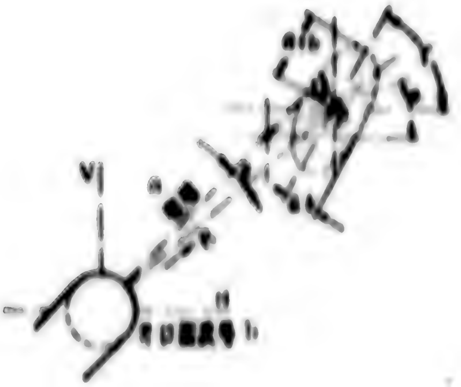


Figure 4. Spatial Positional Relations of Round Waveguide and Elliptically Polarized Wave

Key: a. Sighting axis
b. Open end round waveguide

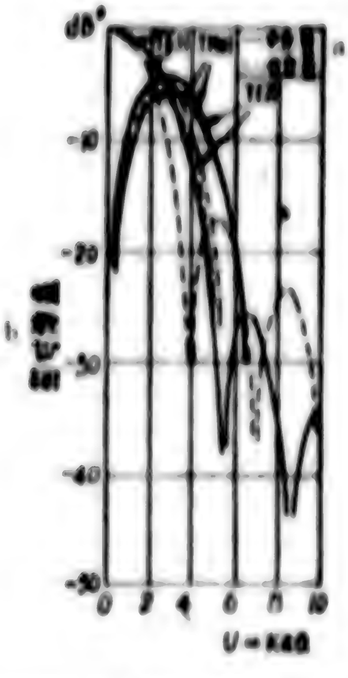


Figure 5. Radiation Patterns of Various Modes in Large-Diameter Round Waveguide

Key: a. Decibels
b. Relative gain

In the operation of multimode automatic tracking satellite systems, the tracking error θ is generally much less than zero (for example, $\theta < 0.01°$), so that $\cos\theta \approx 1$, $\sin\theta \approx \theta$, $u = ka\sin\theta = ka\theta$. When $\theta \ll 1$ ($u = ka\theta < 0.1$), equations 1 and 2 can be simplified to the following (using the approximate formula $J_0(u) \approx 1 - \frac{u^2}{4}$, $J_n(u) \approx \frac{u^n}{2^n \cdot n!}$ when $u \approx 0$):

for the TE_{11} wave

$$\left.\begin{aligned} E_\theta &= E_0 \frac{J_1(ka\theta)}{ka\theta}\sin\phi \approx \frac{E_0}{2}\sin\phi \\ E_\phi &= E_0 \frac{J_1'(ka\theta)}{1-\left(\frac{ka\theta}{1.841}\right)^2}\cos\phi \approx \frac{E_0}{2}\cos\phi \\ E_r &= 0 \end{aligned}\right\} \qquad (4)$$

for the TM_{01} wave

$$\left.\begin{aligned} E_\theta &= E_0 \frac{ka\theta J_0(ka\theta)}{1-\left(\frac{ka\theta}{2.405}\right)^2} \approx E_0 ka\theta \\ E_\phi &= 0 \\ E_r &= 0 \end{aligned}\right\} \qquad (5)$$

for the TE_{21} wave

$$\left.\begin{aligned} E_\theta &= E_0 \frac{J_2(ka\theta)}{ka\theta} 2\sin 2\phi \approx \frac{E_0 ka}{4}\theta\sin 2\phi \\ E_\phi &= E_0 \frac{J_2'(ka\theta)}{1-\left(\frac{ka\theta}{3.054}\right)^2}\cos 2\phi \approx \frac{E_0 ka}{4}\theta\cos 2\phi \\ E_r &= 0 \end{aligned}\right\} \qquad (6)$$

for the TE_{01} wave

$$\left.\begin{aligned} E_\theta &= 0 \\ E_\phi &= E_0 \frac{J_0'(ka\theta)}{1-\left(\frac{ka\theta}{3.833}\right)^2} \approx -\frac{E_0 ka}{2}\theta \\ E_r &= 0 \end{aligned}\right\} \qquad (7)$$

It can be seen from Figure 5 that when the angle θ is very small ($u < 0.1$), the sum signal (TE_{11}) is unchanging, and the difference signal (TM_{01}, TE_{21} and TE_{01}) can be expressed as an oblique line whose slope is $dG/d\theta$ (where G is the voltage gain of the higher mode radiation direction pattern for a nondirectional antenna), which has different values for the different higher modes, and is also related to the radius a of the open waveguide and the wavelength λ, so that we use the normalized slope S:

$$S = \left(\frac{dG}{d\theta}\right) \Big/ \left(\frac{2\pi a}{\lambda}\right)^2 ; \qquad (8)$$

where $(2\pi a/\lambda)^2$ is the ideal gain for the open circular waveguide antenna. From equations 4-8 we can calculate the normalized slopes:

TM_{01} (θ component)	-9.22 dB
TE_{21} (ϕ or θ component)	-10.28 dB
TE_{01} (ϕ component)	-11.67 dB.

If we make the circular waveguide openended antenna the initial radiation source of a Cassegrain antenna, because the various higher harmonics have a different reflectivity distribution over the parabolic surface, there will be about a 0.5 dB difference between the slopes for the various higher modes, and accordingly for the circuit combining two difference signals it is necessary to provide slope compensation, while in the case of the slope for TE_{21} the ϕ and θ components are equal, so that no slope compensation is necessary.

B. Excited Voltage

In order to give the problem under study universal applicability, we assume that an elliptically polarized wave is produced from wave source P (see Figure 5) and from the reversibility of the antenna we find the voltage excited within the antenna's feeder waveguide. If the electric field vector at point P is E_s, then the elliptically polarized wave generally can be considered as composed of two circularly polarized wave components rotating in opposite directions. Viewing wave source P from the antenna, if we denote the counterclockwise rotating circularly polarized component's amplitude as a and the amplitude for the corresponding clockwise component as b, the wave source field vector E_s can be expressed as

$$E_s = (ae^{j\omega t} + be^{-j\omega t})e^{j\gamma}; \tag{9}$$

where γ is the angle between the long axis of the ellipse and the horizontal plane and ω is the angular frequency of the wave source.

It can be seen that the horizontal component E_H of the electric field vector E_s from the source is the real part of equation 9 and the vertical component E_V of vector E_s is its imaginary part, i.e.

$$\left.\begin{aligned} E_H &= \mathrm{Re}\,(E_s) = a\cos(\omega t + \gamma) + b\cos(\omega t - \gamma) \\ E_V &= \mathrm{Im}\,(E_s) = a\sin(\omega t + \gamma) - b\sin(\omega t - \gamma) \end{aligned}\right\} \tag{10}$$

In order to discuss the horizontal component ε_H and the vertical component ε_V of the tracking error θ together, we draw Figure 6. From Figure 6,

$$\left.\begin{aligned} \varepsilon_H &= \theta\cos\phi \\ \varepsilon_V &= \theta\sin\phi \end{aligned}\right\} \tag{11}$$

In the figure, point O gives the antenna axis direction. Because the tracking error θ is extremely small, the electric field vector from the source can be considered approximately as being included in the plane normal to the axis. Below we will use E_H and E_V, ε_H and ε_V to find the voltages of the TE_{11}, TM_{01}, TE_{21} and TE_{01} waves excited in the feeder waveguide.

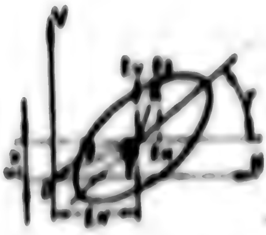


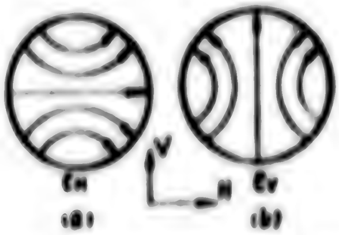
Figure 6. Tracking Error θ and Electric Wave Source Vector

(1) The TE_{11} Wave

The two orthogonal components (a) and (b) excited in the feeder waveguide which is shown in Figure 7 are excited by E_H and E_V respectively; these excited voltages are denoted as e_H and e_V respectively. When the tracking deviation θ is very small, the radiation characteristic of the TE_{11} wave is independent of θ (see Figure 5), and accordingly

$$\left.\begin{aligned} e_H &= \frac{C_{11}}{R} E_H \\ e_V &= \frac{C_{11}}{R} E_V \end{aligned}\right\} ; \qquad (12)$$

where R is the distance between the antenna and the electric wave source (for example a satellite), and the formula uses a propagation attenuation factor 1/R for the electric wave emitted from the source. C_{11} is a constant.



(a) (b)

Figure 7. Two Components of TE_{11} Excited Voltage

(2) The TM_{01} Wave

It can be seen from equation 5 that the excited voltage from the TM_{01} wave is excited only by the θ component E_θ of the electric wave source and not by the φ component E_ϕ. Accordingly at any reference point within the waveguide, the amplitude and phase of the TM_{01} excited voltage are determined by the amplitude and phase of E_θ (R, θ plane or φ plane component), so that the voltage E_D excited by TM_{01} is directly proportional to the E_s vector's φ plane component $\mathrm{Re}(\mathbf{E}_s e^{-j\phi})$, and also directly proportional to the tracking error θ.

$$e_D = \frac{C_{01}}{R}\, \theta \mathrm{Re}\, (E_s e^{-j\phi}); \qquad (13)$$

where C_{01} is a proportionality constant. Substituting into equation 9 we obtain

$$e_D = \frac{C_{01}}{R}\theta[a\cos(\omega t+\gamma-\phi) + b\cos(\omega t-\gamma+\phi)]; \tag{14}$$

From this it can be seen that when the signal received from the electric wave source is a circularly polarized wave (b = 0), the tracking error θ and its azimuth ϕ can be correctly determined by comparing the phase and amplitude of e_H, e_V and e_D in equations 10 and 14. When the wave source signal is an elliptically polarized wave, because in actuality b and γ are not fixed and known, they are very difficult to deal with, and if we use the circular polarization method the tracking error θ and its azimuth ϕ which we find produce cross coupling, resulting in an error. When the wave source signal is linearly polarized (b = a), it can be found from equation 14 that when the direction of polarization is normal to the ϕ plane, i.e. when $\phi = \gamma + \frac{\pi}{2}$, $e_D = 0$ expresses the fact that the electric field E_0 then cannot excite a TM_{01} wave in the antenna aperture, so that tracking based on a linearly polarized wave cannot be effected using the TM_{01} wave.

(3) The TE_{21} Wave

The TE_{21} wave is generally composed of the two orthogonal components shown in Figure 8. Equation 6 corresponds to the radiation fields of the components in Figure 8a, and we now express the components E_θ and E_ϕ of equation 6 in terms of the horizontal plane component E_H and vertical plane component E_V:

$$\left.\begin{aligned} E_H &= E_\theta\cos\phi - E_\phi\sin\phi = \frac{E_0 Ka}{4}\theta\sin\phi \\ E_V &= E_\theta\sin\phi + E_\phi\cos\phi = \frac{E_0 ka}{4}\theta\cos\phi \end{aligned}\right\} \tag{15}$$

Comparison of equation 15 with equation 18 below shows that the horizontal component E_H of the radiation field of the TE_{21} wave is proportional to the vertical component ε_V of the tracking error, while the radiation field normal component E_V is proportional to the horizontal component ε_H of the tracking deviation, and their proportionality constants are equal.

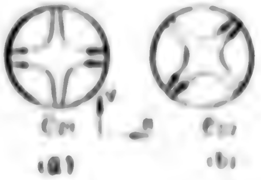


Figure 8. Two Components of TE_{21} Excited Voltage

Allowing for the reversibility of the antenna it is very easy to understand that the excited voltage E_{D_1} of the TE_{21} wave shown in Figure 8a should be directly proportional to the sum of $E_V \varepsilon_H$ and $E_H \varepsilon_V$:

$$e_{D_1} = \frac{C_{21}}{R} (E_V \varepsilon_H + E_H \varepsilon_V). \tag{16}$$

When we try to find the excitation voltage E_{D_2} for the TE_{21} wave shown in Figure 8b, we can rotate the coordinates through 45° to produce new coordinate axes OH' and OV', as shown in Figure 9. If we decompose the tracking error and electric field source vector into H' and V' components and denote them as ε'_H and ε'_V, E'_H and E'_V,

$$\left.\begin{aligned} \varepsilon'_H &= \frac{1}{\sqrt{2}}(\varepsilon_H - \varepsilon_V) \\ \varepsilon'_V &= \frac{1}{\sqrt{2}}(\varepsilon_H + \varepsilon_V) \\ E'_H &= \frac{1}{\sqrt{2}}(E_H - E_V) \\ E'_V &= \frac{1}{\sqrt{2}}(E_H + E_V) \end{aligned}\right\} \tag{17}$$

The relative positions of this coordinate system and the electric field distribution shown in Figure 8b are the same as the relative positions of the initial coordinate system and the electric field distribution shown in Figure 8a, and accordingly the magnitude of e_{D_2} should be proportional to the sum of $E'_V \varepsilon'_H$ and $E'_H \varepsilon'_V$, so that we obtain

$$e_{D_2} = \frac{C_{21}}{R} (E'_V \varepsilon'_H + E'_H \varepsilon'_V);$$

Substituting into equation 17 we obtain

$$e_{D_2} = \frac{C_{21}}{R} (E_H \varepsilon_H - E_V \varepsilon_V). \tag{18}$$

The summed electrical voltage e_D from the orthogonal components of the excited voltage from the TE_{21} wave described above is

$$\begin{aligned} e_{ED} &= \sqrt{e_{D_1}^2 + e_{D_2}^2} \\ &= \frac{C_{21}}{R} \sqrt{(E_H^2 + E_V^2)(\varepsilon_H^2 + \varepsilon_V^2)} \\ &= \frac{C_{21}}{R} |E_s| \theta_t \end{aligned} \tag{19}$$

Clearly the magnitude of the voltage excited by the TE_{21} wave is proportional to the magnitude of the source's electric field and the magnitude of the tracking error and is independent of the magnitude of any of the vector components.

No matter what type of polarization the electric wave source has, if the power is constant, regardless of the direction of the tracking deviation, provided the magnitudes are the same, then the magnitude of the total voltage of the TE_{21} wave excited in the antenna aperture will be fixed. Accordingly, the TE_{21} wave can be used for automatic tracking with any type of polarization.

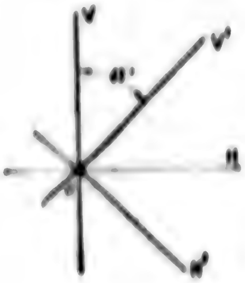


Figure 9. Coordinates for Finding e_{θ_2}

(4) The TE_{01} Wave

It can be seen from equation 7 that the excited voltage of the TE_{01} wave is excited by the ϕ component of the electric field source, and its magnitude is proportional to the tracking error θ, and that the electric source ϕ component cannot excite a TE_{01} wave in the antenna aperture. Accordingly in practice the TE_{01} and TM_{01} waves are generally combined as a tracking mode.

3. Angular Error Detection Methods and Cross Coupling

A mode coupler (see Figure 16) is used in the antenna feeder system of satellite communication ground stations to couple out the fundamental (sum signal) and higher mode (difference signal) components described in section 2B and feed them to the tracking receiver so as to obtain a direct current error voltage output which is proportional to the horizontal component ϵ_H of the tracking error and a direct current error voltage which is proportional to its vertical component ϵ_V. This method is called the angular error detection method. The angular error detection methods are different for tracking using different higher modes and tracking using waves of different polarizations emitted by the satellite. Below we discuss several angular error detection methods which have already been used extensively.

The main index used to evaluate the various angular error detection methods is cross coupling. When the cross coupling is large, the tracking pull in range, tracking speed and acceleration capability are poor, so that tracking is not smooth. Below we will discuss the magnitude of cross coupling in several angular error detection methods.

For TE_{11} and TM_{01}: From equations 10, 12 and 14 of section 2B, the tracking error excited voltage obtained from the mode coupler will be

$$\left.\begin{aligned} e_H &= \frac{G_{11}}{R}\left[a\cos(\omega t+\gamma)+b\cos(\omega t-\gamma)\right] \\ e_V &= \frac{G_{11}}{R}\left[a\sin(\omega t+\gamma)-b\sin(\omega t-\gamma)\right] \\ e_D &= \frac{G_{11}}{R}\,\theta\cdot\left[a\cos(\omega t+\gamma-\phi)+b\cos(\omega t-\gamma+\phi)\right] \end{aligned}\right\}, \tag{20}$$

If this excited voltage is subjected to the angular error detection method shown in Figure 10, an automatic gain control amplifier is first used to normalize the difference signal to the sum signal, so as to eliminate common amplitude changes resulting from path loss effects, after which the normalized sum and difference signals are passed through a phase comparator and phase multiplier, and the high frequency component filtered out, yielding the angular error output voltages U_H and U_V. If we let b' = b/a, then we obtain from equation 20:

$$\begin{aligned} \frac{1}{\theta}e_H e_D &= \left[\cos(\omega t+\gamma)+b'\cos(\omega t-\gamma)\right] \\ &\quad\cdot\left[\cos(\omega t+\gamma-\phi)+b'\cos(\omega t-\gamma+\phi)\right] \\ &= \left[(1+b')\cos\omega t\cos\gamma-(1-b')\sin\omega t\sin\gamma\right] \\ &\quad\cdot\left[(1+b')\cos\omega t\cos(\gamma-\phi)\right. \\ &\quad\left.-(1-b')\sin\omega t\sin(\gamma-\phi)\right]; \end{aligned}$$

and accordingly

$$\begin{aligned} \frac{1}{\theta}\overline{e_H e_D} &= (1+b')^2\cos\gamma\cos(\gamma-\phi)+(1-b')^2\sin\gamma \\ &\quad\cdot\sin(\gamma-\phi) = (1+b'^2)\cos\phi+2b'\cos(2\gamma-\phi) \\ &= \left[(1+b')^2\cos^2\gamma+(1-b')^2\sin^2\gamma\right]\cos\phi \\ &\quad+2b'\sin2\gamma\sin\phi; \end{aligned}$$

From this we obtain the error voltage output in the horizontal direction U_H:

$$\begin{aligned} U_H &= \frac{\overline{e_H e_D}}{|e_H||e_D|} = A\left\{\theta\cos\phi\right. \\ &\quad\left.+\frac{2b'\sin2\gamma}{(1+b')^2\cos^2\gamma+(1-b')^2\sin^2\gamma}\cdot\theta\sin\phi\right\}, \end{aligned}$$

and from equation 11

$$U_H = A\left\{\theta_H+\frac{2b'\sin2\gamma}{(1+b')^2\cos^2\gamma+(1-b')^2\sin^2\gamma}\cdot\theta_V\right\};$$

Similarly we can obtain

$$U_V = A\left\{\frac{2b'\sin2\gamma}{(1+b')^2\sin^2\gamma+(1-b')^2\cos^2\gamma}\cdot\theta_H+\theta_V\right\};$$

and we can write

$$\begin{bmatrix} U_H \\ U_V \end{bmatrix} = A\begin{bmatrix} 1 & \dfrac{2b'\sin2\gamma}{(1+b')^2\cos^2\gamma+(1-b')^2\sin^2\gamma} \\ \dfrac{2b'\sin2\gamma}{(1+b')^2\sin^2\gamma+(1-b')^2\cos^2\gamma} & 1 \end{bmatrix}\begin{bmatrix} \theta_H \\ \theta_V \end{bmatrix} \tag{21}$$

where A is an arbitrary gain coefficient. Equation 21 expresses the cross coupling between the angular error output voltages U_H and U_V and the tracking errors ε_H and ε_V. The cross coupling is governed by the ellipticality b' and the inclination γ of the ellipse's major axis. For circular polarization, with b = 0, the cross coupling is zero, and the angular error output voltage is proportional to the tracking error. For noncircular polarization there is cross coupling. For linear polarization, with b = 1, when $\gamma = \phi + \frac{\pi}{2}$, then $\left[\begin{smallmatrix} U_H \\ U_V \end{smallmatrix}\right] = 0$.

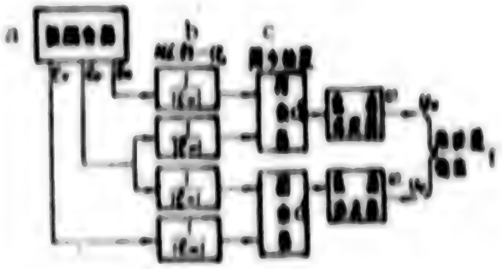


Figure 10. TE_{11} and TM_{01} Angular Error Detection Method (Four Channel Method)

Key:

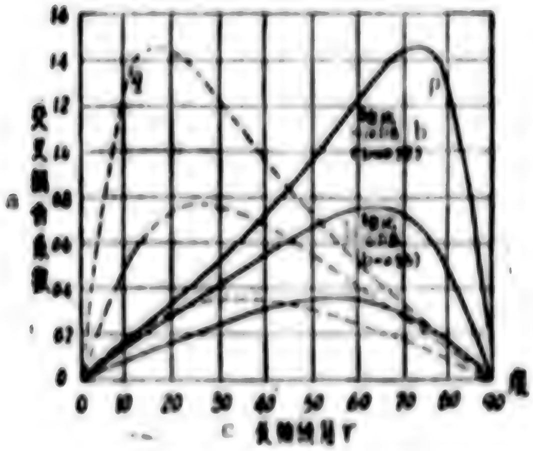
a. Mode coupler	d. Phase multiplier
b. AGC normalization	e. Low pass filter
c. Synchronous detection	f. Angular error output

For an arbitrary polarization, the cross coupling constants from equation 21

$$P = \frac{2b' \sin 2\gamma}{(1+b')^2 \cos^2\gamma + (1-b')^2 \sin^2\gamma},$$

$$q = \frac{2b' \sin 2\gamma}{(1+b')^2 \sin^2\gamma + (1-b')^2 \cos^2\gamma}$$

are shown in Figure 11. Clearly when the axis ratio b' is small, for example b' < 3 dB, the cross coupling component is relatively small, and a multimode tracking approach based on TE_{11} and TM_{01} is suitable.



Key:

a. Cross coupling coefficient
b. Axis ratio
c. Long axis inclination

Figure 11. Angular Error Output Voltage Cross Coupling for Arbitrary Polarization

The angular error detection method shown above in Figure 10 is the four-channel processing method. For a satellite beacon signal which is close to circularly polarized, it is necessary only to receive only one TE_{11} wave orthogonal component, as shown in Figure 12, which simplifies processing; this is the two-channel path method which is currently in common use. By a derivation analogous to that for the four-channel method we can obtain

$$\begin{bmatrix} U_a \\ U_r \end{bmatrix} = A\begin{bmatrix} 1 & \frac{2b'\sin 2\gamma}{(1+b')^2\cos^2\gamma+(1-b')^2\sin^2\gamma} \\ 0 & \frac{1-b'^2}{(1+b')^2\cos^2\gamma+(1-b')^2\sin^2\gamma} \end{bmatrix}\begin{bmatrix} a_a \\ a_r \end{bmatrix}, \tag{22}$$

Here it is apparent that for circular polarization with b = 0, there is no cross coupling, so that we can obtain the error index directly. There will be cross coupling for elliptical polarization with a small axis ratio.

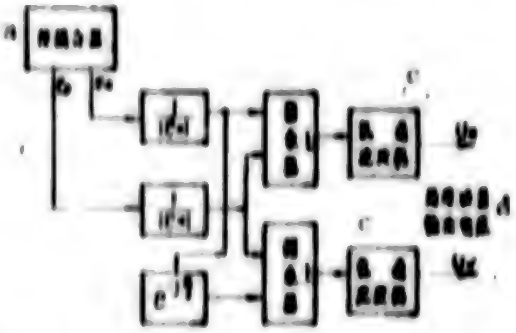
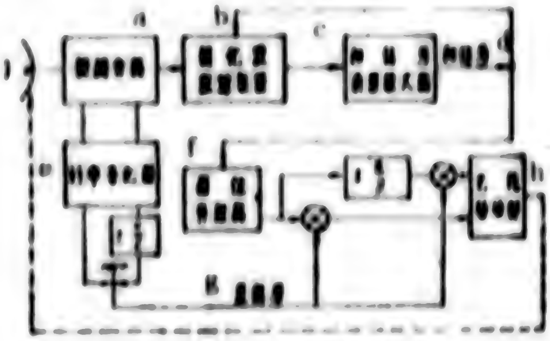


Figure 12. TE_{11} and TM_{01} Angular Error Detection Method (Two-Channel Method)

Key:

a. Mode coupler
b. Phase multiplier
c. Low pass filter
d. Angular error output voltage

For TE_{11}, TM_{01} and TE_{01}: Figure 13 shows an angular detection method which is suitable for use with waves of arbitrary polarization. It can use the TE_{11}, TM_{01} and TE_{01} waves as the sum and difference signals or the TE_{11} and TE_{21} waves described below as the sum and difference signals; the only difference is in the coupling method and design of the mode couplers.



Key:
a. Mode coupler
b. Polarized wave tracking equipment
c. Sum signal preamplifier
d. Sum signal
e. Inclination equalizer
f. Phase compensator
g. Difference signal
h. Nonlinear driver

Figure 13. Angular Error Detection Method for Arbitrary Polarization (two-channel method)

From equation 5, for the TM_{01} wave, $E_\theta = E_0'ka\theta$ and $E_\phi = 0$. Accordingly,

$$E_H = E_0'ka\theta\cos\phi, \qquad (23)$$
$$E_V = E_0'ka\theta\sin\phi;$$

By comparison with equation 11 we can obtain the voltage e_1 of the TM_{01} wave excited in the antenna aperture:

$$e_1 = k_\theta\,(\varepsilon_H E_H + \varepsilon_V E_V); \qquad (24)$$

From equation 7, for the TE_{01} wave we obtain

$$E_\theta = 0,\quad E_\phi = -\frac{E_0'ka}{2}\theta,$$

and accordingly

$$E_H = \frac{E_0'ka}{2}\theta\sin\phi, \qquad (25)$$
$$E_V = -\frac{E_0'ka}{2}\theta\cos\phi;$$

comparing with equation 11 we can obtain the excitation voltage e_2 for the TE_{01} wave:

$$e_2 = -k_\phi(\varepsilon_H E_V - \varepsilon_V E_H); \qquad (26)$$

Here k_θ is a constant which is proportional to the inclination of the TM_{01} wave's radiation pattern, and k_ϕ is a constant proportional to the inclination of the TE_{01} wave's radiation pattern. Because k_θ and k_ϕ are not equal, an inclination equalizer must be used, after which e_1 and e_2 are mixed under phase orthogonality conditions to produce the difference signal e_D, and if the phase error at the time of mixing is δ, then

$$e_D = e_1 e^{-j(\frac{\pi}{2} + \delta)} + e_2; \qquad (27)$$

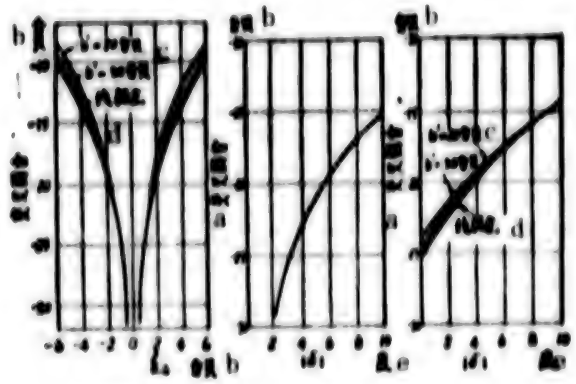
Substituting equation 10 into equations 24, 26 and 27, if for the two-channel method shown in Figure 13 we multiply e_D by $[-2\sin(\omega t + \gamma)]$ and $[2\cos(\omega t + \gamma)]$ to obtain its direct current component and then multiply by the normalization factor $2/[(k_\theta + k_\phi)(a + b)]$, we obtain the angular error output voltage

$$\begin{bmatrix} U_H \\ U_V \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \varepsilon_H \\ \varepsilon_V \end{bmatrix}; \qquad (28)$$

where

$$a_{11}=\frac{2}{(a+b)(1+k_e)}\{a+ak_e\cos\delta-b\cos 2\gamma$$
$$+bk_e\cos(2\gamma+\delta)\};$$
$$a_{12}=\frac{2}{(a+b)(1+k_e)}\{-b\sin 2\gamma-ak_e\sin\delta$$
$$+bk_e\sin(2\gamma+\delta)\};$$
$$a_{21}=\frac{2}{(a+b)(1+k_e)}\{-b\sin 2\gamma+ak_e\sin\delta$$
$$+bk_e\sin(2\gamma+\delta)\};$$
$$a_{22}=\frac{2}{(a+b)(1+k_e)}\{a+ak_e\cos\delta+b\cos 2\gamma$$
$$-bk_e\cos(2\gamma+\delta)\};$$
$$k_e=k_g/k_{g0}$$

It can be seen that in this formula a_{12} and a_{21} give the magnitude of the cross coupling; calculated results are shown (in dB) in Figure 14. Figure 14 shows the maximum values of a_{12} and a_{21} as γ varies from 0° to 180°, with a, b, k_g and δ fixed and with different values of b'. In actual calculations, in addition to specifying the axis ratio b', we must also know the direction of rotation of the electric field vector of the elliptically polarized wave. If the direction is counterclockwise then a = 1, b = (b' - 1)/(b' + 1); if it is clockwise, then b = 1, a' = (b' - 1)/(b' + 1). The figure shows the rather large cross coupling magnitudes obtained for these two directions.



(a) (b) (c)

Figure 14. Cross Coupling in Tracking Method Using TE_{11}, TM_{01} and TE_{01}

Key:

a. Cross coupling
b. Decibels
c. Decibels
d. Linearly polarized
e. Degrees

(a) $\delta = 0$
(b) $K_g = 0$
(c) $K_g = 1$ decibel

For TE_{11} and TE_{21}: Equations 16 and 18 give the TE_{21} wave voltages for the two orthogonal electric fields excited in the mode coupler:

$$
\begin{aligned}
e_{D_1} &= \frac{C_{21}}{R}\,(E_V\varepsilon_H + E_H\varepsilon_V),\\
e_{D_2} &= \frac{C_{21}}{R}\,(E_H\varepsilon_H - E_V\varepsilon_V);
\end{aligned}
\qquad (29)
$$

As described above, the inclinations of the radiation patterns of the two orthogonal components of the TE_{21} wave are equal, and if the coupling losses in the mode coupler are identical for e_{D_1} and e_{D_2} of equation 29 then we have $k_\theta = k_\phi = k$, and we do not need to use the inclination equalizer. If we use the phase orthogonality relationship and make use of e_{D_1} and e_{D_2}, if the phase error δ at that time is zero, then

$$e_D = e_{D_1}e^{-j\frac{\pi}{2}} + e_{D_2} = 2ka(\varepsilon_H \sin(\omega t + \gamma) + \varepsilon_V \cos(\omega t + \gamma)); \qquad (30)$$

The quantity e_D in this equation only includes the counterclockwise rotation component a of the electric field vector of the satellite beacon signal; if e_{D_1} is mixed with e_{D_2} while leading the latter by $\frac{\pi}{2}$, then e_D only includes the clockwise rotation component b of the electric field e vector.

In the TE_{11} and TE_{21} multimode tracking method, if $k_\theta = k_\phi = k$ and $\delta = 0$, then the direct current voltage proportional to ε_H and ε_V obtained by synchronous detection of e_D in equation 30 will not produce any cross coupling. If $k_\theta \neq k_\phi$, $\delta \neq 0$, then there will be cross coupling, and we can derive an equation for it; the result will be the same as equation 28, indicating that the magnitude of the cross coupling given in Figure 14 is similarly applicable.

From this it can be seen that for arbitrary polarization, if we use TE_{11}, TM_{01} and TE_{01}, or TE_{11} and TE_{21}, or other higher modes, the reason that there is cross coupling is that the directional patterns for the two higher mode components have different inclinations, and the mode loss in the mode couplers will be unequal, and when they are mixed under phase orthogonality conditions there will be a phase error.

The tracking method which combines the TE_{11} and TE_{21} waves is suitable for beacon signals with arbitrary polarization and does not require inclination equalization, in addition to which the number of higher modes used is rather small, so that the use of the tracking method employing TE_{11} and TE_{21} with polarization tracking equipment and a phase compensator (see Figure 13) may be considered good; currently it is in extensive use in international standard satellite ground stations and satellite tracking and control stations, as well as domestic satellite communications ground stations which use linear polarized waves.

4. High Frequency Multimode Tracking Systems

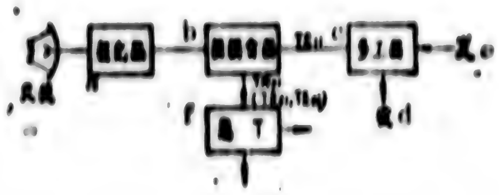


Figure 15. Satellite Ground Station High-Frequency System

Key:

a. Polarizer	d. Receiver
b. Mode coupler	e. Transmitter
c. Multiplexer	f. Magic T
	g. Antenna

A high frequency satellite ground station is shown in Figure 15. The antenna receives the basic TE_{11} mode and sends it to the feeder horn. Currently most communication satellites emit a circularly polarized wave; in the future they may emit linearly polarized waves. Between the left side of the multiplexer and the antenna circular waveguide is used, and between the right side of the multiplexer and the transmitter-receiver a rectangular waveguide is used. The wave arriving from the antenna feeder must enter the polarizer (which in reality is a polarization changer) and be converted into a linear wave which is required for the rectangular waveguide.

In order to enable the antenna to track the satellite, the satellite emits a beacon signal. The frequency of the beacon signal is different from the message frequency. A filter is used inside the tracking mode coupler to separate the two signals. The beacon signal excites the tracking modes in the tracking mode coupler. The tracking modes are TM_{01}, TE_{21} and TE_{01}. The shapes of the mode couplers differ with the nature of the tracking mode. Multimode tracking systems include single-channel, two-channel, three-channel and four-channel types. With more than two channels there must be great agreement between the channels, which is hard to receive, so that at present the main emphasis is on using signal signal channel tracking systems.

5. The Mode Coupler

Mode couplers couple the higher modes from the horn to produce the tracking error signal. The requirements for mode couplers are: when the tracking mode (the "difference" mode) coupling losses are small, reflection is small, and the degree of coupling of the "sum" signal mode (the "sum" mode) is small. A mode coupler which uses the TM_{01} mode in a circular waveguide as the mode is shown in Figure 16. A coupling hole is cut in the opposite surface of the circular waveguide so that the TM_{01} mode in the waveguide is coupled with the TE_{10} mode [sic] in the rectangular waveguide. The front of the square waveguide has a bandpass filter and is connected to a double T connector. The circular waveguide has a pair of coupling holes in the horizontal and vertical directions as shown in Figure 16b to meet the requirements for elevation and azimuth tracking.

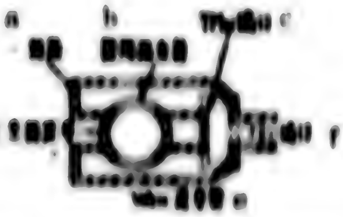


Figure 16a. Cross Section Through Main Waveguide With Coupling Slots and Magic T

Key:
a. Short circuit
b. Circumference coupling slot
c. TM_{01} end
d. Main round waveguide
e. W_{G14} waveguide arm
f. TE_{11} end

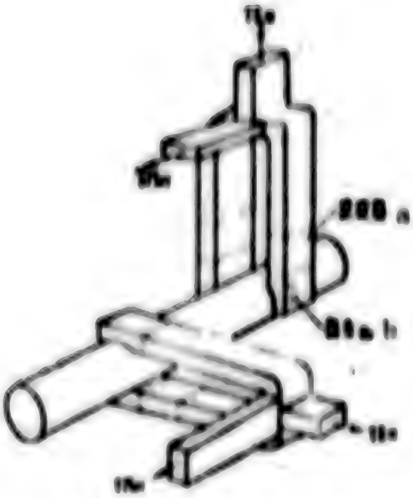


Figure 16b. TM_{01} Mode Coupler

Key: a. Filter b. Coupler

For single-channel tracking systems, a TM_{01} mode coupler only requires one pair of coupling holes. The Marconi company (U.K.) uses this type of design, and its waveguide feeder unit is as shown in Figure 17. The diameter of the circular waveguide is chosen so that it will pass the TM_{01} mode and intercept the TE_{21} mode. T_a is the transmitter connection and R_a is the receiver connection.

A mode coupling waveguide which uses the TE_{21} mode in a round waveguide has 8 equidistant coupling holes around the circumference as shown in Figure 18. In order to assure that the TE_{21} mode field will be circularly polarized, all of the coupling holes have an equal degree of coupling with the rectangular waveguide. If a slotted waveguide is a uniform circular waveguide, the slots can be

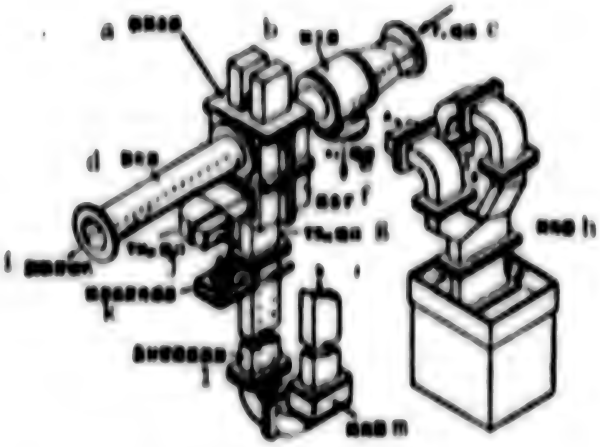


Figure 17. Waveguide Feeder

Key:

- a. Mode coupler
- b. Diplexer
- c. T_0 end
- d. Polarizer
- e. R_0 end
- f. Mixer T
- g. TE_{11} end
- h. Phase modulator
- i. To feeder horn
- j. TM_{01} end
- k. Feeder temperature sensor
- l. [illegible]
- m. Isolator

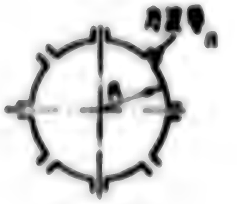
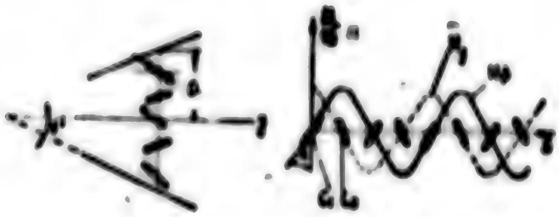


Figure 18. TE_{21} Mode Coupler

Key: a. Square waveguide



(a) (b)

Figure 19.

Key: a. Amplitude

parallel to the axis. If the slots are cut in a cone, as shown in Figure 19(a), neighboring slots both must be inclined at an angle α from the sides. If a circle is drawn through the centers of the 8 slots, magnetic field components H_ϕ and H_z with amplitude distributions around the circular circumference of the conical waveguide as shown in Figure 19(b) can be obtained.

The coupling holes of the tracking mode coupler of the Yokosuka ground station in Japan have series-connected resonators and waffle iron filters, the coupled "difference" modes are TM_{01} and TE_{01}, and the four coupling holes are symmetrically distributed. The tracking uses two frequency bands: first it searches with a 4,000 MHz broad beam, and after the object is acquired it automatically shifts to 18,000 MHz narrow-beam precision tracking.

8480
CSO: 8111/0368

APPLIED SCIENCES

SHIPBOARD DATA MULTIPLEX SYSTEM DESCRIBED

Shanghai DIANZI JISHU [ELECTRONICS TECHNOLOGY] in Chinese No 8, 1980 pp 1-3

[Article by Zhu Wuhua [2612 3670 5478] and Wang Hongzhen [3076 7703 2182]: "The Shipboard Data Multiplex System: A New Design To Prevent Interference Between Signals On-Board Ship"]

[Text] Naval ships include a group of platforms, every one of which is necessary to overall operation. Accordingly, extensive communications is required within each platform and between platforms. As a result of the extensive development of satellite systems, long range low frequency systems and secure data links, considerable importance has been accorded to communications between platforms. But in the system as a whole, insufficient consideration has been given to communications within platforms, a fact which has greatly disappointed engineers, because as newer and more advanced technology is introduced into weapons, guidance and other shipboard systems, communications needs within the platform will increase greatly. If such customary connection methods as point-to-point wiring are used on ships today, many economic and technical problems may result. The marine systems division of the U.S. company Rockwell International has proposed a new approach, the shipboard data multiplex system, which is now under development.

The shipboard data multiplex system (SDMS) is a general-use information transmission system which carries out all data transmission for systems on board ship, such as weapon direction systems, command and control consoles, combat information centers, damage control centers, guidance subsystems and the control of displays and electrical generating machinery. The SDMS uses a main trunk cable for information transmission. The cable is laid out according to a standard wiring plan and is not altered when the ship's electronic equipment is changed. The SDMS is a modular design so as to provide sufficient transmission bandwidth for the various types of platforms (from an escort vessel to an aircraft carrier, from a submarine to a land-based experimental installation) and to assure the needed-level of redundancy. The component modules consist of the multiplex cables, traffic controllers (TC), area multiplexers (AM), and remote multiplexer shared electronics (RMSE) along with input-output units (IOU). Figure 1 is a block diagram of an SDMS structure. The IOU's are designed to be adaptable to standard naval junction boxes and are located as close as possible to the user subsystems. Each compartment which has large amounts of signal generating or receiving equipment is provided with one or more remote multiplexers (RM). Compartments with many remote control centers are equipped with area

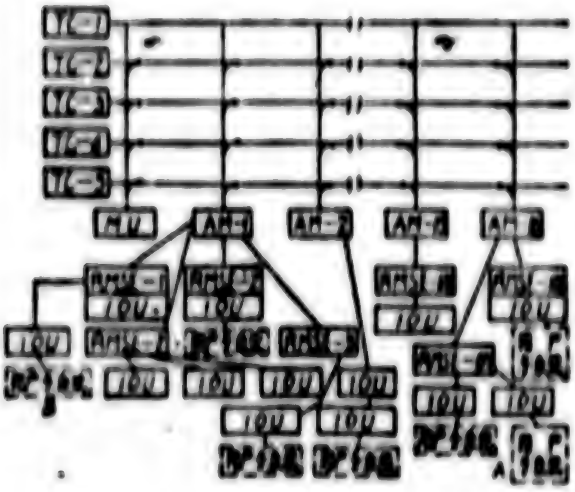


Figure 1. Structure of the SDMS

[boxes labeled in Chinese all read "user subsystem"]

multiplexers (AM), and the traffic controllers are distributed among several interior compartments. The interior communications maintenance personnel's compartment also has a maintenance unit (MU). When in use, a baseline system has 5 primary data buses, 5 traffic controllers, 8 area multiplexers, 64 remote multiplexers and 1 maintenance unit. This avoids interactions between the various systems.

System Operation

Suppose that user subsystem B requires an immediate connection with user subsystem A's interface signals. These signals are first fed into the local input-output unit, after which they are fed to an RMSE-127 remote multiplexer at the right [as published] of user subsystem A; this remote multiplexer accumulates samples of all signals arriving from user subsystem A and transmits them to area multiplexer AM-16 in the compartment, which translates this baseband time-division multiplexed [TDM] signal into a frequency-division multiplexed [FDM] signal in one of 4 data channels in the 40-80 MHz band. Input to the five trunk lines, each of which covers the entire ship, is controlled by a traffic controller on each of the trunk lines. At the terminal, the signal arriving from user subsystem A is sent by a route which is the reverse of that just described to every user subsystem B: it is received from the trunk line by the closest area multiplexer, AM-1, and is there converted to a baseband time-division multiplexed signal so that it can pass through the closest RMSE-1 and the IOU closest to user subsystem B and immediately be distributed to that user subsystem. It should be noted that this entire process essentially occurs in real time, which means that the SDMS is not a store-and-forward system. When every user subsystem signal is converted from its original analog, synchronous, digital or discrete form, it is transmitted in TDM form through the remote multiplexer at the same time as it is transmitted in FDM form through the area multiplexers. None of the information is stored at any point in the system, so that it is real-time data.

Multiplexing in Three Domains

In order to satisfy simultaneously the requirements of modularization, growth of capabilities, flexibility and interface standardization as well as to transmit many signals along a very long shipboard cable path, SDMS uses multiplexing in space, frequency and time.

In the spatial domain, the means of meeting these requirements is to have each of the five primary multiplex buses which pass through the entire ship operate independently, and to use all of them simultaneously to transmit signals from the various subsystems on board. Any signal can use any trunk cable, and in fact successive transmissions of a specific signal can use all the cables at random. The SDMS can operate with only one or two trunks. But increasing the number of trunks gives increased assurance of operating capabilities as well as the ability to carry increased numbers of signals.

In the frequency domain, frequency division multiplexing is used to divide the trunk multiplex cable into five channels, of which four are used to transmit digital information and the fifth to control the traffic controllers. Accordingly, a 5-trunk SDMS design allows any ship subsystem to transmit its signal to any other subsystem via any of 20 different data channels.

Any shipboard subsystem signal transmitted through the SDMS is first converted into the time domain, i.e., is sampled in time, and even though the initial forms of signals may differ they are all converted into standard digital signals. The digitized signal samples are combined into a signal by the frequency-division multiplex method and transmitted through one of the data channels on the multiplex trunk. A receiving remote multiplexer separates these time-sampled signals after they are reconverted.

Mechanization of System Control

The means of mechanizing control in the SDMS is its completely asynchronous and distributed form. Asynchronous distributed control was selected only after thorough analysis of the technological and operational needs of shipboard signal transmission. It has the following main capabilities: (1) such signal parameters as message length, update rate and priority are used in setting up a data exchange path between user subsystems exclusively by local control; (2) when a new approach is developed, it is easy to change the signal transmission parameters and system connection method, in addition to which the expense is small, on the spot testing and verification are simple, and if there is a malfunction it does not disable all of the ship's information transmission capabilities or degrade their quality.

Distributed control means that the basic control mechanism which resolves such questions as what data will be transmitted at what time and from what signal source to what terminal is not located in a central unit but is distributed throughout the system. In the SDMS, data transmission between two subsystems is controlled by two plug-in programmable read only memories (PROM), one located in the SDMS terminal serving the signal source and the other at the output end. The coding in these two PROM's controls the subsystem message update rate, priority, address and the like, quite independently of all other messages in the system. In order to set up a new digital data path through the SDMS it is only necessary to provide two suitable interface cards (input and output) and compose the suitable PROM program for the remote multiplexers closest to the originating and receiving units.

Some multiplex systems give all control to a control response computer. All of the signal transmission requirements for the several hundred users on a ship or submarine must be communicated to the computer by means of a software program. This computer program is very long, and only when all subsystem designs are complete can this step be begun; before it is completed, it is necessary to carry out a large number of tests in order to debug it. Because there are likely to be computer malfunctions, the subsystems may also be affected.

User Interface With SDMS

The normal user signal input point is the remote multiplexer. The remote multiplexer has two functions: (1) as an input-output section, able to handle several dozen input-output modules or units (IOM, IOU); (2) as a redundant sharing electronics device (RMSE). Any synchronous data can be handled by inserting the proper card for the analog or discrete IOM in question into a slot in the input-output unit, thus meeting the signal distribution needs of all user subsystems in a compartment, i.e., all types of signals used in electronic systems on board ship are converted into a standard digital form required for transmission within the SDMS. Every IOM card can be inserted into any redundant RMSE unit. The RMSE unit contains part of the SDMS system's "brain," i.e., the SDMS message characteristics are determined by the data stored in PROM, and then the "service flag" is set to start system transmission.

Reliability and Maintenance Characteristics

Because of the critical nature of certain signals which are transmitted, and because the multiplex system itself functions as the ship's central nervous system, it was recognized during development of the SDMS that it must have high reliability. The system reliability standards involve finding formulas for system reliability parameters on the basis of many different redundancy designs and investigating the relationship of system characteristics to mean time between failures [MTBF]. These studies of reliability tradeoffs in design lead to derivation of the optimum system reliability which can be implemented with a given unit MTBF's. The standards based on compromise design are as follows: the reliability of an individual user circuit which does not require repair over a 24-hour period and has no IOM redundancy is specified as 0.999. The reliability of a system which does not require repair over a 24-hour period is specified as 0.9999999; one system malfunction is defined as disconnection or degradation of service of 10 percent of all SDMS user circuits. Accordingly, the design shown in Figure 2 which has this high redundancy level involves dividing the system into several redundant paths, so that redundancy increases in accordance with importance. In other words, the closer an element is to the system's center, where all signals would be affected by a malfunction, the greater its redundancy.

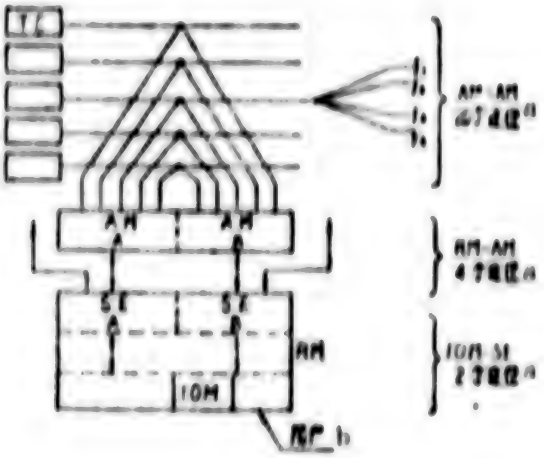


Figure 2. SDMS Redundancy and Reliability

Key: a. ...channels b. user

In the SDMS design care was taken to assure that in any expected malfunction there would not be a sudden interruption of signal transmission throughout the ship but rather a gradual degradation. This design concept requires that if the ship loses its electric power supply a backup emergency battery can be used.

Advantages of the SDMS: Cost and Weight

Comparing the SDMS with the usual point-to-point wiring systems in terms of cost and weight, it must be admitted that the decisive factor is the number of signals carried by the conventional system and processed by the SDMS. Figure 3 shows the general relationship between cost and number of signals. On a CGN or similar ship these curves intersect at 1,500 signals, which means that if the SDMS carries a sufficient number of signals it can immediately produce a cost saving. The relationship is similar as regards weight. If an SDMS is used on a CGN-type ship, about $9 million can be saved in the initial acquisition and installation, and the weight decreased by 50 tons. If a similar weight analysis is made for air cushion and hydrofoil vessels, the saving proves to be about 6 tons. On dynamic lift ships this weight decrease is particularly important because it actually increases range, speed and payload.

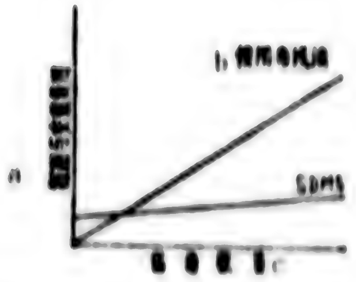


Figure 3. SDMS Cost Advantages

Key: a. Acquisition and installation costs
b. Ordinary wiring method
c. Number of signals

Conclusion

In summary, the SDMS can be used on a wide range of platforms and on future land experimental bases. All any ship needs is a single multiplex system. This system may offer many interface designs, including absorbing the remote multiplexer function into the main user equipment. In addition, the SDMS logically leads to interface standardization throughout the ship. Because of its modular design and distributed control characteristics, the SDMS is a system with a low incidence of malfunctions. Because of the asynchronous character of the SDMS, when the system has an overload resulting from noise or loss of signal bandwidth caused by equipment malfunction, it exhibits gradual degradation. When the ratio of signal load to usable system bandwidth increases, there is no signal loss, but all users are uniformly allocated the remaining usable frequency width according to a priority method. Accordingly the net effect of a failure mode is to slightly increase transmission time for all users; at the same time, the average message update rate is lowered slightly.

The modular distributed control structure also results in high system reliability. The entire SDMS is based on protected difengxian [0144 7364 7145] electronics technology, and its smooth operation does not require any technological breakthroughs.

Last, but far from least in ship design, the system features local control all message transmissions. This eliminates interaction between several user subsystems and also interaction between user subsystems and the ship design cycle, and accordingly, is an advance toward the construction of even more effective fighting ships.

BIBLIOGRAPHY

1. Johnson, D.S., and Blackwell, L.M. "Shipboard Data Multiplex System," Conference Proceedings, Military Electronics Defense Expo 19, 6-8 October 1976, pp 225-246.

2. Bold, Norbert T.; Wapner, Martin; and Blackwell, L.M. "Shipboard Data Multiplex System (SDMS)—A New Design for Lower Ship Cost and Improved Flexibility," NAVAL ENGINEERS JOURNAL, Vol 88, 1976, pp 245-256.

3. Simmons, J.L. "Design for Change--The Impact of Changing Threats and Missions on System Design Flexibility," NAVAL ENGINEERS JOURNAL, Vol 87, No 2, 1975, p 121.

4. Kaune, J.K. "Methods To Reduce Cost and Time of Ship Modernization and Ship Maintenance," NAVAL ENGINEERS JOURNAL, Vol 87, No 2, 1975, p 88.

8680
CBO: 8111/0368

BRIEFS

CHINESE LANGUAGE LETTERPRESS--Chengdu, March 19 (XINHUA)--A PH-5A Chinese-language letterpress composing machine has begun mass production in this city in China's southwest. Developed by Sichuan University after an 11-year research effort, the machine has a storage capacity of 310,000 characters and a typesetting potential of 150 characters per minute. Designed for rapid operation and low electric consumption, the machine is operated by a typesetter working from a keyboard. [Text] [OW200026 Beijing XINHUA in English 1245 GMT 19 Mar 81 OW]

CSO: 4020

Petroleum

AUTHOR: ZHANG Kai [1728 1956]
LUO Zhili [5012 1807 4539]
ZHANG Qing [1728 3237]
DAI Jinxing [2071 6855 2502]
YAO Huijun [1202 1979 0689]

ORG: All of the Scientific Research Institute of Petroleum Exploration and Development, Beijing

TITLE: "Classification of Basins and Potential Hydrocarbon Resources in China"*

SOURCE: Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese No 4, 1980 pp 1-18

TEXT OF ENGLISH ABSTRACT: The three old plates that constituted the stable core of the Chinese continent since pre-Cambrian were the Tarim plate, the North China plate and the Yangze [Changjiang] plate. They were surrounded by the Siberian plate, the Indian plate and the Pacific plate. Later development of the Chinese continent brought into being the following five plates: the Dzungaria-Songliao contraction sea plate, the Tarim plate, the North China plate, the Gansu-Qinghai-Tibet plate and the South China plate.

Petroliferous basins were formed between the Chinese plates and their surrounding plates. According to the mechanism of plate tectonics and conditions favorable

[Continuation of SHIYOU XUEBAO No 4, 1980 pp 1-18]

for the occurrence of oil, we may classify the principal basins into 10 types in 5 categories as follows:

I. Cratonic Basins
   Type I_1 Intracratonic single cycle basins
   Type I_2 Intracratonic polycyclic basins
   Type I_3 Intracratonic rift basins
II. Suture Belt Basins
   Type II_1 Contraction sea basins
   Type II_2 Intermontane basins or piedmont basins between suture belts
III. Arc-trench System Basins
   Type III_1 Fore-arc basins
   Type III_2 Back-arc basins
   Type III_3 Intra-arc basins
IV. Deltaic Basins
V. Revived Fault Basins.

Of all these basins, the intracratonic polycyclic basins should be given priority in exploration, and the contraction sea basins and back-arch basins should come next. However, new areas for exploration in the deltaic basins along the continental margin and the intracratonic single cycle basins should not be overlooked.

* A full translation of this article is being prepared for publication in the CR/Econ Series.

AUTHOR: TONG Chongguang [4547 1504 0342]

ORG: College of Geology, Chengdu

TITLE: "Some Characteristics of Petroleum Geology of the Rift System in Eastern China"

SOURCE: Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese No 4, 1980 pp 19-26

TEXT OF ENGLISH ABSTRACT: The "second subsidence belt" in eastern China is probably a large continental rift system formed on the eastern Chinese continent since late Mesozoic. It follows a north, northeasterly trend, over 4000 km long and about 250~450 km wide, comparable to the recent eastern African rift system. The occurrence of this system might have been due to the subduction of the Pacific-Eurasian plate and collision of the Indo-Australian plate with the Eurasian plate.

The oil-gas reservoir traps within the rift basins are predominantly of the structural and stratigraphic types. The structural traps in Tertiary are chiefly in the tilted fault blocks, rolling anticlines and anticlinal drape structures. The stratigraphic traps from Precambrian to Mesozoic are chiefly a variety of burial fault blocks and volcanic rocks.

[Continuation of SHIYOU XUEBAO No 4, 1980 pp 19-26]

Considering the fact that there are many major oil and gas fields in the rift basins in the world, it should be possible to find more oil gas reserves in the rift basins in eastern China.

AUTHOR: DAI Jinxing [2071 6855 2502]

ORG: Scientific Research Institute of Petroleum Exploration and Development, Beijing

TITLE: "Preliminary Research on Natural Gas in Coal Series in China"

SOURCE: Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese No 4, 1980 pp 27-37

TEXT OF ENGLISH ABSTRACT: The results of our analyses of the composition of gases from some coal beds in China show that: (1) hydrocarbon gas predominates the components of gases from the coal beds, while methane claims absolute predominance in hydrocarbon gases; and (2) different types of coal have different contents of heavy hydrocarbons, as low as 1.4 - 2.6 percent for anthracite and as high as 5-18 percent for gas coal, gas rich coal, rich coal, coking coal and lean coal, together with a small amount of oil.

Many of the characteristics of oil and gas shows discovered in the coal series in China are quite similar to those of the above-mentioned hydrocarbon components. In the Upper Triassic and Permian systems in the Sichuan and Shanganning basins, gas pools formed by coalification have been discovered. Wet-gas pools are found in the Xiangxi coal series in the central and northwestern parts of Sichuan, producing gas coal and rich gas coal with 8-15 percent heavy hydrocarbon content.

[Continuation of SHIYOU XUEBAO No 4, 1980 pp 27-37]

There are three stages in the formation of hydrocarbons during coalification: (1) the early dry gas stage--with lignite (consolidated brown coal and unconsolidated brown coal) and peat, primarily forming methane; (2) the wet gas stage--with sub-bituminous coal, jet coal, gas coal, rich coal, coking coal and lean coal, forming methane, 5-20 percent heavy hydrocarbons and a small amount of oil; and (3) the late dry gas stage--with lean coal and anthracite, forming a large amount of methane and some heavy hydrocarbons (generally 2-3 percent).

The geologic conditions for gas accumulation in coal series are: (1) prolong subsidence of coal basins; (2) cap rock of regional extent; and (3) uplift of long development.

AUTHOR: WU Zhenlin [0702 2182 2651]
TONG Wu [0157 2976]
LIU Anjian [0491 1344 0256]
ZOU Quansheng [6760 3123 3932]
ZHANG Deyuan [1728 1795 0337]

ORG: WU, TONG and LIU all of Liaohe Oil Field; ZOU, Shengli Oil Field; ZHANG, Daqing Oil Field

TITLE: "Earthquake and Anomalies in Oil and Water Well Performances Observations in Bohai Bay"

SOURCE: Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese No 4, 1980 pp 39-48

TEXT OF ENGLISH ABSTRACT: The embryonic process of earthquakes tends to affect the oil fields adjoining its focus, which finds its manifestation in reflections of anomalies in the production of oil and water wells. In the case of oil wells, under normal conditions of production when no measures of enhancement of any kind are taken, any increase of production by a wide margin or any sudden increase or drop in output, pressure build-up in producers and intermittent flow in individual temporarily closed strippers are all expressions of anomalies; while in the case of water wells, anomalies are expressed in the abnormal changes in water level, water conductivity and radon content of water. All these anomalies may be determined through analysis of interferences.

[Continuation of SHIYOU XUEBAO No 4, 1980 pp 39-48]

In essence, changes in the performance of oil and water wells reflect the relationship between the interstitial water pressure of the rock body and the deformation of and damage done to the rock body, similar to the hydrofracturing of oil wells. An earthquake, its embryonic stage and outburst, is a process of accumulation, release and readjustment of strain energy; and in the performance curves of oil and water wells it is expressed as a process of sudden change and resumption to normal. Therefore, anomalies occurring in oil and water wells before and after the earthquake are closely related to its tremors and may be used in earthquake predictions.

AUTHOR: CHEN Binghua [7115 3521 5478]

ORG: North China Oil Field

TITLE: "On the Relationship between the Distribution of the Buried-Hill Oil Fields and the Evolution of Paleostructures and Paleogeomorphological Features in Central Hebei"

SOURCE: Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese No 4, 1980 pp 49-55

TEXT OF ENGLISH ABSTRACT: In recent years, many buried-hill oil fields have been found in the middle part of Hebei at depths of several thousand meters. Different explanations of the formation and distribution of these oil fields have been advanced. This paper attempts to describe the relationship between the inside structures of the buried hills, the characteristics of development of their paleogeomorphological features and the distribution of the oil fields, based mainly on the abundant seismic and drilling data available.

Data of deep wells drilled to the basement are integrated with aeromagnetic data, showing that the pre-Cambrian basement in central Hebei was an uplift at the early stage. The changes in the thickness of the Paleozoic and Mesozoic strata bear witness to the process of development o' the inside structures of the buried hills

[Continuation of SHIYOU XUEBAO No 4, 1980 pp 49-55]

and the time of their formation by the end of the Mesozoic as a result of two tectonic movements. The different paleogeomorphological landscape is the result of pre-Tertiary truncations. The development of the inside structures of the buried hills and the landforms is found to be quite regular and has a close relationship with the distribution of buried-hill oil fields. Of particular interest is the NNE faulting which lasted very long and released enough energy to form prominent paleogeomorphological features. It is also an important factor in the formation of the Tertiary oil basins and distribution of buried-hill oil fields.

AUTHOR: YANG Peishan [2799 1014 1472]
LI Gongzhi [2621 0501 3112]

ORG: Both of the North China Oil Field

TITLE: "Development of Carbonate Reservoirs in the Renqiu Oil Field"

SOURCE: Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese No 4, 1980 pp 57-64

TEXT OF ENGLISH ABSTRACT: Development of the Renqiu Oil Field started in 1976. It is an oil field of the buried-hill type, with oil contained in reservoirs in the Wumishan formation of Sinian, but generated from the overlying Paleogene which serves both as a source rock and a cap rock. The Wumishan formation, totaling 2100 meters thick, is a suite of dolomites with fractures and intergranular pores. The reservoirs, crisscrossed with faults and fractures, have a unified pressure system and oil-water contact. Wells are cased to the top of the reservoirs and completed barefooted. Producers are high-yielding, with daily production per well reaching several hundred to thousand tons.

Thanks to the good intercommunication in the reservoirs, the low natural energy in the reservoirs is compensated for by means of water-flooding from the bottom for pressure maintenance. For three years since its application, pressure and oil

[Continuation of SHIYOU XUEBAO No 4, 1980 pp 57-64]

production have been kept constant. Observation wells are drilled in the different parts of the structure to watch oil and water movement in the various stages of development. However, testing in production and injection wells reveals that severe heterogeneity of physical properties of the reservoirs exists in parts of the oil field, which will certainly complicate prediction of reservoir performance and make it difficult for us to control oil and water movement.

AUTHOR: YUAN Yirang [5913 4135 6245]
WANG Wenxia [3769 2429 3174]

ORG: Both of Shandong University

TITLE: "On the Elements of Two-phase (Oil and Water) Immiscible Flow Displacement Problem"

SOURCE: Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese No 4, 1980 pp 65-76

TEXT OF ENGLISH ABSTRACT: This paper deals with the two-phase immiscible flow displacement problem. Only elastic compression of the rocks is taken into account, and no consideration is given to capillary action.

The finite element methods are applied in the solution of the pressure equation and the saturation equation:

$$\nabla \cdot (M \nabla P) = H\beta^* \frac{\partial P}{\partial t}$$

$$\nabla \cdot (Mf \nabla P) = H\phi \frac{\partial S}{\partial t}$$

For the solution of the saturation equation, the "prediction-correction" methods are also used. Based on data from the fields, models have been devised for predicting performances of water-drive reservoirs with very satisfactory results.

AUTHOR: WANG Xiuyuan [3769 0208 0997]
WANG Chuanzhu [3769 0278 2691]

ORG: WANG Xiuyuan of the Institute of Microbiology, Chinese Academy of Sciences, Beijing; WANG Chuanzhu of the Scientific Research and Design Institute of Daqing Oil Field

TITLE: "Microbial Polysaccharide Produced from Crude Oil and Its Applicability in Secondary Oil Recovery"

SOURCE: Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese No 4, 1980 pp 77-85

TEXT OF ENGLISH ABSTRACT: This paper deals with a strain of bacterium Brevibacterium viscogenes nov. sp. 74-230, which produces extracellular polysaccharide from crude oil and its fractions. The effects of ages of the inoculum, several kinds of crude oil and their fractions, and contents of crude oil on the synthesis of polysaccharide were investigated.

When crude oil was used as the sole carbon source (12 percent, w/v) in 50 or 240 l fermentors, 8.0 g/l of polysaccharide were obtained. The changes of hydrocarbon components after fermentation were analyzed. They indicated that the bacterium strain had mainly utilized n-alkane.

[Continuation of SHIYOU XUEBAO No 4, 1980 pp 77-85]

The fermented gummy solution was diluted and used as a driving fluid in laboratory scale model experiments. When the injection volume corresponds to 20 percent of the pore volume, the secondary oil recovery is enhanced to about 9 percent of the initial reserves.

AUTHOR: YANG Chenghan [2799 2110 3352]
REN Jinying [0117 6930 5391]

ORG: None

TITLE: "The Characteristics of Hydraulics and Mixture in Batching Product Pipeline"

SOURCE: Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese No 4, 1980 pp 87-98

TEXT OF ENGLISH ABSTRACT: Due to differences in properties and fluctuations in the hydraulic performances of crude oil and refined products in batching operations, studies should be made of the complex process of the operational performances in the pump stations before making the pipeline design. The guiding principles of technological designs involving reasonable methods of transportation and regulation, etc., are then determined. The concept of "cycle working range" is used in this article in the analysis of hydraulic performances.

The amount of interface produced in batching products line presents some statistical features. Mastery of these features can guide the distribution and treatment of the mixture. By utilizing the formulas commonly employed very accurate results may be obtained in the calculation of the amount of interface, but the effects caused by batching operations are not considered in those formulas. Some examples cited in this paper explain the cases in detail.

[Continuation of SHIYOU XUEBAO No 4, 1980 pp 107-113]

It has been proved that this procedure not only extends the use of petroleum fractions enthalpy chart, but also has higher accuracy and is more convenient to use.

9717
CSO: 4009 END

END OF

FICHE

DATE FILMED

4/6/81

B